Vol. VIII. No. 8. August 15, 1911.

THE

PSYCHOLOGICAL BULLETIN

GENERAL REVIEWS AND SUMMARIES

RECENT LITERATURE ON THE BEHAVIOR OF THE LOWER INVERTEBRATES

BY PROFESSOR S. O. MAST

Johns Hopkins University

Protozoa.—The paper by Day and Bentley (5) is on the same general subject as that by Stevenson Smith which appeared in the Journal of Comparative Neurology and Psychology in 1908. The results stated in these two papers are mutually confirmatory and the experimental methods used are essentially the same. The problem set for the paramecia was to get out of a tube so small that they could not turn around. There can be no doubt, judging from the records presented, that the time required to accomplish this feat decreased rapidly. The authors (p. 73) comment on this result as follows: "It appears from the experiments (1) that paramecium is capable of modifying within a few minutes its usual avoiding reaction; the lateral turn is so increased and prolonged as to permit the animal to reverse its long axis in a narrow circular tube; (2) that the effect of this modification remains for some time independently of external changes induced. Observations of this nature are taken as evidence of learning. . . . Nevertheless, it is questionable whether this kind of 'learning' involves consciousness; whether it is not as well interpreted as the result of purely organic processes."

Mast's paper (13) consists of two parts. The first is devoted primarily to the question of orientation, the second to the question of the stimulating efficiency of different colors. To the comparative psychologist the following quotation contains perhaps the most interesting point in the paper. "By referring to Figure 1 it will be seen that after one pseudopod came in contact with the illumination

and was stopped, the amœba did not at once proceed in the opposite direction so as to avoid the light, but sent out other pseudopods at only a slight angle with the first, apparently trying to get around the obstacle in this way. The character of the response did not change after the first pseudopod came in contact with the light, nor did it change after the second and third came in contact with it. But after the fourth became exposed the direction of motion was nearly reversed. This indicates that the reaction was modified, that the response to a given stimulus depends upon the preceding experience" (p. 267). Whether or not such changes in reactions can be considered as evidence of learning I am unable to say.

The author finds that certain amœbæ under certain conditions orient, though not very accurately, and move in a general direction from the source of light; and that a sudden and sharp increase of light intensity causes a cessation in movement. He maintains that orientation is due to the inhibition of the formation of pseudopods in the more highly illuminated side of the animal, which is in all probability caused by change of intensity, and that there is no evidence whatever that orientation is regulated by direction of the rays through the tissue, as demanded by Loeb's first theory of orientation, or the angle between the rays and the surface, as demanded by his second theory, or by difference of intensity on symmetrically located sensitive elements, *i. e.*, by stimulation of symmetrically located sensitive elements by light continuously in proportion to the absolute intensity on them, as demanded by his third and last theory.

Both prisms and filters were used in the experiments on color. The responses to the monochromatic light and to the impure colors produced by the filters were essentially alike. Violet, green, yellow, orange and red had only very slight effect on the movement of amœbæ, but sudden exposure to the blue caused instant cessation of movement. "The response to the blue is so striking and that to the other colors so very slight that there can be no question as to the specific effect of the blue (430–490$\mu\mu$). That is, the effect of different parts of the prismatic solar spectrum on Amœba is not proportional to the energy contents, for the energy gradually increases as one proceeds from the violet toward the red end, whereas the region of maximum stimulation for Amœba is in the blue, from which it decreases toward both ends. Nor it is proportional to the brightness as judged by the human eye, for the yellow is much brighter than any other part of the spectrum" (p. 274).

Loeb and Maxwell (12) tested the responses of the following organ-

isms to different colors: ***animals:*** Daphnia, and nauplii of ***Balanus perforatus*** (positive and negative); ***plants:*** Chlamydomonas. Nothing is given regarding methods except that both prism and Rowland gratings were used to differentiate the rays. It was found that "the strongest gathering of [Daphnia] occurs in the green," that of Balanus (positive) in the green toward the yellow, that of Balanus (negative) in the green, red and violet, and that of Chlamydomonas in the green. Regarding Chlamydomonas the authors say (p. 197), "We have repeated this experiment with absolutely the same result on nine different days." It is hardly probable that the term 'absolute' is used here in its generally accepted sense. At any rate I have never found a group of organisms that would respond to a given stimulus *absolutely* the same on nine different days.

The authors also state that acids, especially CO_2, produce "positive heliotropism in fresh-water animals (Daphnia and Copepoda) and free swimming algæ (Volvox)" (p. 197). They conclude, "It is therefore obvious that, as far as our experiments go, the heliotropic reactions of swimming animals are identical with those of swimming algæ" (p. 197). How much evidence have we here indicating that 'heliotropism' in plants and animals is identical? I am not certain just what the authors mean by 'heliotropism,' but the senior author usually uses this term to indicate orientation in light. Assuming that this is meant by the term in the paper under consideration, I cannot see how the results necessarily have any bearing on the question involved, for in no instance was it ascertained whether the aggretions in the spectrum were due to orientation or to random movements and avoiding reactions, as is the case, *e. g.*, when Chlamydomonas, Euglena, and other similar organisms collect in a vertical beam of light producing a bright spot in a dark field. But even if the aggregations in the spectrum were due to orientation in all instances, the results would have only a very insignificant bearing on the problem stated, for surely the fact that Chlamydomonas, an organism which is on the border line between plants and animals, responds to the different rays of the spectrum like Balanus and Daphnia, and the fact that Volvox, an organism claimed by zoölogists as animal and by botanists as plant, and closely related to Chlamydomonas, is affected by acids in its response to light like Daphnia, is not very convincing evidence that "heliotropism in plants and animals is identical," especially when it is known that the process of orientation in Daphnia is different from that in Chlamydomonas and Volvox, and that gradual reduction in temperature causes both Chlamydo-

monas and Volvox, if they are positive in a given light intensity, first to become quiet and then strongly negative in the same intensity, whereas it has no such effect on the response of Daphnia.[1]

Moreover, the experimental results of the botanists with but one or two exceptions agree in showing that the region of maximum stimulating efficiency in the spectrum for all plants tested is in the violet, indigo, or blue, *i. e.*, between 390$\mu\mu$ and 490$\mu\mu$. In the most recent extensive work on this subject Blaauw (1909) maintains that the stimulating efficiency at the maximum, which is in the indigo at 465$\mu\mu$, is 2,600 times greater than it is in the green, yellow or red. Loeb and Maxwell found the maximum for Daphnia and Balanus in the green well toward the yellow, *i. e.*, between 490$\mu\mu$ and 560$\mu\mu$. It is evident then that even with reference to this point there is no general agreement between the reactions of plants and animals to light.

The statements of these authors intimating that the work of the botanists on distribution of stimulating efficiency in the spectrum must be discredited because a "majority of [these] experiments were made with the aid of colored screens and . . . the few experiments made with a spectrum gave rather indefinite results" (p. 196) is, in my opinion, not in accord with the facts. In the first place a majority of botanists used prisms to differentiate the light rays. In looking over the names of all of the authors mentioned in a comprehensive review of the recent literature on this subject I find that out of the twelve mentioned only three used screens exclusively, and that only one of these three, Sachs, would be considered at all prominent in this line. In the second place, the experimental methods in most instances were excellent. In this connection I would mention particularly Guillemin (1858), Strasburger (1879), Wiesner (1879), and Blaauw (1909), at least two of whom made use of chromatic spectral colors of such purity that the Fraunhofer lines could readily be distinguished. And in the third place, a careful reading of the original papers of these authors can scarcely fail to convince any one that the results obtained are fairly definite, conclusive, and mutually confirmatory.

Vermes.—In either of Galloway's two papers (6, 7) will be found an excellent description of the reactions of a male annelid to the phosphorescence of the female during the process of mating, and this is the only point of especial interest to students of behavior or comparative psychology. It is, as far as I know, the only instance in which

[1] See MAST's *Light and the Behavior of Organisms*, pp. 274–279.

phosphorescence in organisms has been shown to be of unquestionable ecological importance. Just before mating, which probably occurs periodically about every 26 days during several summer months, the females are found at dusk swimming about near the surface of the water. At first they are only very slightly luminous, but later they quite suddenly become acutely phosphorescent, particularly in the posterior three-fourths of the body. At this phase they swim rapidly through the water in small, luminous circles two inches or more in diameter. "The male first appears as a delicate glint of light, possibly as much as 10 or 15 feet from the luminous female. They do not swim at the surface, as do the females, but come obliquely up from the deeper water. They dart directly for the center of the luminous circle and . . . seize the female with remarkable precision, when she is in the acute stage of phosphorescence" (6, 3). "So far as could be observed, the phosphorescent display is not repeated by either individual after mating. Very shortly the worms cease to be luminous and are lost" (7, 16). The authors lean toward the opinion that the luminosity of the male is useless and that the phosphorescence is a by-product of 'a form of metabolism.' I assume they would maintain that its origin was accidental, and had nothing to do with its present function in mating.

The function of the eyes and the nature of the stimulus constitute the main problems in Mast's investigation (14). Four different species were studied. The reactions in all were essentially the same. Specimens with the eyes removed either by gouging them out or by cutting the head off responded to light after the wounds were healed by becoming more active when exposed in strong illumination, but there was no indication of orientation. Normal specimens of all four species orient fairly accurately, as did also the amputated anterior ends which contained the eyes.

These results, the author maintains, show clearly that the eyes of marine turbellaria function in the process of orientation. He also holds that the increase in activity when the illumination is increased is dependent upon the amount of light received, that is, continued intensity. It is not a response to change of intensity. This conclusion is based largely upon the fact that the increase in activity does not take place until some time after the intensity of the light has been changed. With reference to the nature of the stimulus which regulates orientation he says, "Our evidence is not conclusive, although it indicates that it is due to change of intensity" on the sensitive tissue in the eyes. This evidence may be found in the original paper.

The problems examined in Morgulis' paper (17) are: (1) Does the worm react as a succession of separate segments or as a unit organism? (2) "What determines the worm's movement in a definite direction?"

The author confirms Friedländer in his conclusion that there is coördinate movement in the two parts of worms cut in two and sewed together. He also removed a section of the nerve-cord and still found coördinate movement, but he says that if either anterior or posterior end is lightly stimulated, contraction waves passing backward or forward do not pass the 'nerveless region.' "Muscular contractions unless very strong are insufficient to induce a state of muscular activity in an adjacent part." But his main argument in favor of the idea that the worm does not "react as a chain of segments but rather as a unit" (p. 623), is based upon the observation that when the posterior end is turned to the right or left, the anterior end immediately turns in the opposite direction, while there is no movement in the central portion. This the author intimates is due to an impulse passing rapidly from one end of the worm to the other, and not to a successive action of segments. His assumption that the tendency of organisms to move in a definite way, *e. g.*, the tendency of a worm to move in a straight line, is a neglected factor in behavior, probably applies to the observations of a certain few investigators, but in my opinion it cannot be maintained to have a general application. It simply means that the behavior of organisms is not determined solely by external factors. And this idea is the keystone in the work of Darwin on *The Power of Movement in Plants*, published in 1880, and is prominent in the work of Jennings and others.

Echinoderms.—When an Ophiuroid comes in contact with a solid and is then pulled away it usually returns to the spot touched. This is among the most important points established in Cowles' interesting paper (3). It shows an apparent after-effect of the constant stimulus, a sort of primitive memory of past stimuli. The ray which made the contact acts as leader for some time after, and movement occurs in the direction indicated by this ray, unless some other stimulus, *e. g.*, strong light, acts in opposition. The author maintains that movement up vertical walls is not a response to gravity, as many hold, but is due to a tendency of continuing in a given direction, so that whenever the animal meets an obstruction it does not turn to the right or the left but goes up. The tube feet function in feeding by seizing particles and passing them toward the mouth. This occurs even in rays cut from the body. They distinguish between food and in-

organic bodies by means of chemical stimuli, for they take pellets of filter paper soaked in meat juice and reject those soaked in sea water. These animals are negative in their reactions to light. They go toward vertical walls but not toward shadows on the floor. The author does not analyse these reactions, but the movement toward dark walls is in all probability due to the reduction of light from this direction owing to the wall, while the failure to go toward the shadow on the floor indicates that the shadow does not sufficiently obstruct the light from its direction to produce a directive influence.

A second paper by Cowles (4) relates to the behavior of the starfish. Echinaster is decidedly migratory. These animals "use their tube feet in moving about over the sand in much the same manner as human beings use their legs" (p. 97). Both Echinaster and Astropecten live in regions exposed to the brightest light and they are both positive in their photic reactions. No preference is shown for any ray as leader, but orientation is more accurate when a ray is directed toward the light than it is when the region between the rays is thus directed. Removal of the eye-spots does not interfere with the accuracy of orientation. This is in harmony with the observations of Mangold (1909). A "prism of water mixed with a little Higgins water-proof ink" was arranged over a box so as to make the illumination gradually more intense from one end toward the other. The starfish persistently moved toward the brighter end. The author assumes that this proves that the direction of the rays does not control the direction of movement. The same objection however may be offered here as has frequently been offered to a similar apparatus used by Oltmanns and others. If one were to place the eye in the position of the starfish in the apparatus, it is undoubtedly true that the difference in illumination of the two ends of the prism could be clearly detected, which means that these ends act as secondary sources of light, that at the thinner end of the prism being the more intense.

Moore's paper (16) consists mainly of an attack on Jennings' position with reference to the righting reaction of the starfish. Jennings points out that the righting reaction in the starfish is a regulatory response, without which those specimens which chanced to become turned over would have to perish. He suggests that the injury of remaining on the dorsal surface may be due to several factors: (1) cessation of locomotion and consequently of "finding and capturing food"; (2) pressure of the gills on the bottom resulting in possible injury and impeding respiration; (3) displacement of internal

organs that may be "harmful to their proper functioning." He describes in detail just what occurs during the process of righting but attempts no further analysis of this response. He maintains that certain specimens which have a tendency to use a given ray constantly in initiating the righting reaction could be taught to use other rays if the tube feet of the given ray were repeatedly stimulated with a glass rod so as to prevent them from attaching.

(1) Moore fastened a glass plate so that it touched the gills of a starfish 'lightly' as it crawled under, and found that it moved right on and did not turn over. (2) He turned a glass plate to which a starfish was attached over so that the dorsal surface was down and again found that the starfish did not turn over. (3) He injured the active rays "(*a*) [by] irritating the ventral groove of the arm by rubbing it with a glass rod, (*b*) [by] treating the tips of the arm with a few drops of *n*/10 acid" (p. 239), and found that he could thus make specimens use a ray to initiate the righting reaction which they formerly did not use in this way. These results, he maintains, show that Jennings is wrong, first, in his statements as to the cause of the righting reaction, and second, in his conclusion as to the cause of change in the ray used to initiate this reaction.

He concludes (1) that the righting movements "are due only to the positive stereotropism of the tube feet," and (2) that "a starfish cannot be taught to use an arm which is ordinarily passive" (p. 239). But he maintains (p. 237) that his observations agree with the assumption of Loeb that "the mechanism of the righting movements is the result of coördinating and inhibiting impulses, which are transmitted to the various arms by the ventral nerve ring."

I am unable to see how either of the author's experiments on the righting reactions has any bearing on the position that Jennings takes as to the nature of this response; for all that his experiments teach is that this reaction is not primarily a response to gravity or to contact stimulation of the gills, and Jennings certainly does not maintain that it is. In neither of the experiments was the normal functioning of the starfish appreciably hindered, whereas the central idea in Jennings' statement is that the righting movement is a regulatory response by means of which the starfish avoids conditions which tend to interfere with the normal functions of its organs. The author intimates that Jennings injured the tube feet by stimulating them, and that the starfish used a new ray to initiate the righting reaction, not because of the experience of repeated trials but because it could not use the other rays owing to injury. I am not familiar with the

details of Jennings' experiments on this point, but it certainly seems possible to stimulate without injury the tube feet sufficiently to prevent them from attaching, and that is all that Jennings did.

Upon what the author bases his conclusion that "a starfish cannot be taught to use an arm which is ordinarily passive" (p. 239) is not clear. He says nothing about having attempted to teach one. Surely the fact that it uses a new ray when all others are injured has no bearing on the question of learning.

The author's final conclusion that the righting movements "are due only to the positive stereotropism of the tube feet" (p. 239) does not seem to be in harmony with his preceding statement that "the mechanism of the righting movements is the result of coördinating and inhibiting impulses, which are transmitted to the various arms by the ventral nerve ring" (p. 237), unless he assumes that the coördination and inhibition are due to the stereotropism of the tube feet. But what is this stereotropism which the author maintains gives a "much simpler explanation of the righting movements" than that suggested by Jennings? Unfortunately he gives us no answer to this question. "The tube feet," he says (p. 235), "are positively stereotropic. Therefore the arms twist and turn until all of the tube feet are in a position to be in contact with a surface." Is this any more than saying that the starfish turns over because it has a tendency to take a position such that its feet can function? Surely no one who has ever seen one of these animals on its back would be unreasonable enough to maintain that there is anything in the nature of an attractive force between the tube feet and the substratum that brings them together. A fly rights itself; it tends to keep its feet in contact with a solid; they are stereotropic. Are not its righting movements as fully explained as are those of the starfish, when it is said that it turns over because its feet are positively stereotropic? And the same might be said with but little modification with reference to the human being. His feet too are stereotropic; they tend to remain in contact with solids. If the author had used the expression 'tendency to come in contact with solids' in place of 'stereotropic,' he would have seen more clearly in what his simple explanation of the righting movements consists, and that the problem involved in the righting movements of the starfish is essentially the same as that involved in the question as to why the human being stands on his feet in place of his head.

Mollusks.—In his investigation on the photic reactions of gastropods, *Littorina litorea* and *Littorina rudis*, Morse (**18**) was unable to confirm Bohn in his conclusion that these animals change

in their response to light from positive to negative and *vice versa* in correspondence with the movement of the tides, and that they retain these periodic changes for some time after being taken from the sea and put into aquaria, exhibiting a sort of primitive memory of the tides. However this may be in regard to Littorina, there are animals in which periodic responses have been fully demonstrated to continue for some time after the periodic changes in the environment which ordinarily accompany them have been eliminated. The worm Convoluta and the crab Idothea studied by Keeble and Menke respectively are notable examples. In plants such reactions have long been familiar.

During the process of locomotion in most of the gastropods, waves are seen to pass either forward or backward over the foot. The principal point that Parker establishes in his paper (19) is that these waves consist of concavities or troughs, not convexities, as generally assumed. With this point established he sets forth a theory of locomotion which consists mainly of the idea that as vertical muscles produce the troughs by contraction, longitudinal muscles extending from the portion raised from the substratum forward to the attached portion draw the elements in the trough forward. This process repeated in succession either forward or backward results in forward movement of the entire animal. This theory is thought to apply equally to the movement of those gastropods in which no waves are seen. In these the author assumes that there are concavities in the foot and that the tissue in them is drawn forward just as in the other, but that the concavities are promiscuously scattered and consequently do not form troughs, so that it would be very difficult to see them.

Arthropods.—The prime object of Banta's investigation (1) was to ascertain (p. 439) "why the one animal, *Cæcidotea stygia*, is a cave inhabitant, while the other, *Asellus communis*, its near relative living in the same region, rarely occurs in caves." The author finds that both of these isopods tend to collect in light of low intensity, but that the surface species becomes positive in its reactions after having been subjected to total darkness for some time. The cave form is much more sensitive to tactile stimuli and vibrations and has much keener discrimination in selecting its food than the surface form. The reactions in general in both forms are highly adaptive and as such would tend to keep Cæcidotea in the caves and to direct Asellus out. The author holds that the habits and structures which eminently fit animals for life in caves are not primarily due to modifications caused by the environment in the caves, but that

the animals now existing in caves had become closely adapted for cave life before they became cave dwellers. He says (p. 485), "Since Asellus is so closely related to Cæcidotea morphologically and physiologically, it would seem that if under stress of circumstances any epigeal animal could suddenly become a cave inhabitant, Asellus might be expected to be capable of undergoing such change in environment." The paper is well written, and there is every evidence that the experimental results are trustworthy. But it seems to me that it could have been advantageously shortened by the elimination of some of the twenty-three tables, many of which cover more than a page.

Hess (8) thinks that the eyes of insects and crabs contain fluorescent substances, and he maintains that the reactions in ultra-violet are in all probability reactions to longer waves produced by the effect of the ultra-violet on the phosphorescent substance. He finds no evidence of such a specific response to the different wave-lengths as would indicate color vision.

In his paper on phototactic reactions, Jackson (11) maintains: (1) That Hyalella, which is normally negative in its reactions to light, becomes positive when dropped into weak solutions of the following substances: hydrochloric, acetic, oxalic acids; ammonium and potassium salts (bromide and iodide); ammonium hydrate, ethyl alcohol and ether. They also become positive in a saturated solution of boracic acid. Tartaric acid and the following substances produce no change: sodium and magnesium salts, potassium and sodium hydrate and potassium carbonate. (2) The strength of solution which produces reversal in reaction varies greatly with different compounds, *e. g.*, in chromic acid 0.0046 per cent. induces the change, whereas in acetic it required 0.01 per cent. and in boric acid a saturated solution. (3) When the animals were put into 25 c.c. distilled water and the chemicals were added very slowly and gradually they remained negative in all cases until they were killed.

He concludes (p. 263), "It is probable, therefore, that these various changes of reaction are due not to chemical changes in the eyes or skin of the animals, but to a sudden stimulation or shock to the nervous system." This conclusion appears to be in direct opposition to that of Loeb and Bohn on this subject, for these authors maintain that the chemicals in the environment, *e. g.*, acids, have a *specific* effect on certain assumed chemical reactions in the sensitive tissue.

McGinnis's article (15) presents the following results: Branchipus

is positive in its reactions to light. It orients with the ventral surface facing the light, no matter whether the source is above, below, or to the side. In total darkness these animals are negative to gravity and come to the surface. In diffuse light they are positive and go to the bottom.

General Papers.—It is well known that certain animals are more sensitive to a given external condition when expanded than when contracted; *e. g.*, earthworms and fly larvæ respond to much weaker illumination when the anterior end is thrust out than when it is withdrawn. Bohn (2) has made observations on a number of other animals in which he says this is true. He attempts to account for this change in sensitiveness on purely physico-chemical grounds. His preliminary assumptions are however so numerous and hypothetical that his explanation is hardly worth considering. For example, the stem of the cœlenterate Veretillum, an approximately cylindrical structure, grows down at the end when it is placed horizontally. This is due to a response to gravity. Bohn observed that in the growing end of a stem there are wave-like contractions which proceed toward the tip, consequently the tip is subjected to alternate periods of contraction and expansion. Now he finds that this structure turns down only during the period of expansion and he *assumes* (pp. 497–501), (1) that the reacting tissue becomes more sensitive during this period; (2) that the upper surface is more sensitive than the lower; (3) that the sensitiveness depends upon a chemical reaction; (4) that this chemical reaction takes place between a hypothetical substance within the tissue and some substance in the environment, *e. g.*, oxygen; (5) that the internal hypothetical substance is lighter than protoplasm and consequently collects at the upper surface. On these assumptions, for none of which, with the possible exception of the first and the third, is there the slightest evidence, he bases his explanation of the response of this organism to gravity. Over one hundred years ago (1806), Knight put forward a similar hypothesis to explain the reaction of plant stems to gravity. This hypothesis, however, has long since been abandoned. All of the other so-called physico-chemical explanations in the paper under present consideration are of the same order, and still the author maintains (p. 501) that his hypotheses "not only explain the known facts but every day lead to the discovery of new ones; they are very fertile working hypotheses, to which the study of phosphorescence . . . gives a certain reality." But what bearing phosphorescence has on these hypotheses he fails to mention. Practically every one aims at a mechanical explanation

of life phenomena and welcomes any advance along this line, but I am of the opinion that there is nothing gained by such crude attempts as have been presented in this paper.

The results obtained in Hess's work (9) have an important bearing on certain rather widely accepted ideas regarding the fundamentals in reactions to light. With the exception of Amphioxus the investigation is confined to the arthropods and mollusks, of which representatives of some fifteen different genera were tested, including the historically important forms, *Porthesia chrysorrœa* and Daphnia. The principal problem in the mind of the author appears to have been to ascertain the distribution of stimulating efficiency in the spectrum. In nearly all instances the light used was a Nernst-lamp prismatic spectrum. In such a spectrum the energy increases fairly regularly from the violet to the red end. Four different methods were employed: (1) aggregation in the spectrum, (2) movement of the eye of Daphnia, (3) contraction of the pupil in cephalopods, (4) activity of Amphioxus and mussels, especially the contraction of the siphons. In all instances the reaction to different intensities of white light was first ascertained and it was found that the reactions to the more intense light corresponded to those in the yellow-green region of the spectrum, and those to the weaker light corresponded to the reactions in the violet and red: *e. g.*, animals which were positive in white light aggregated in yellow-green; those which were negative, in the violet and the red. The author maintains, as others have shown for different organisms, that the reactions of the higher invertebrates are in opposition to the conclusions of Loeb (1) with reference to his ray-direction theory of orientation and consequently non-adaptive reactions, and (2) with reference to his dictum that the photic reactions of plants and animals are 'identical point for point.'

While Hess has shown conclusively that Loeb's experimental results do not warrant his conclusions regarding orientation (others have also pointed this out), I do not think that his evidence in favor of the opposite is conclusive, for in no instance has he eliminated the possibility of orientation to the direction of the rays. In the experiment, *e. g.*, where animals exposed in the entire spectrum move directly toward a given region, it is evident that the light reflected from that region may be the controlling factor in their movement. However, the evidence in opposition to Loeb's second conclusion is convincing, for it is well known that for most plants, as pointed out elsewhere in this review, the region of maximum stimulating efficiency in a spectrum like the one used by Hess is well toward the violet

end, whereas Hess has clearly shown that for all of the higher invertebrates tested it is in the yellow or green.

Holmes (10) after pointing out that all theories of the origin of intelligence based upon the 'psycho-physiology of pleasure and pain' are limited in their usefulness owing to our ignorance concerning the nature of physiological states which accompany given psychic manifestations, and after discussing the point of view of Hobhouse, concludes as follows: "Animals in the course of their instinctive responses encounter stimuli which bring about other responses. These become associated. *According to the nature of the nervous pathways involved, there may be reinforcement of or interference with the original reaction.*[1] Experience brings about an extension of the range of adaptations by the assimilation of congruent reactions and the elimination of acts whose secondary consequences are in the nature of antagonistic and thereby inhibitory responses. Such we may say, by way of expressing a tentative view-point, is the nature of primitive intelligence" (p. 480).

It seems to me that in the assumed nervous control of "reinforcement of or interference with the original reaction" found in this theory we have precisely the same sort of problem as that which we have in the physiological states associated with pleasure and pain, a problem which in the words of the author is 'rather a fruitless one.'

References

1. Banta, A. M. A Comparison of the Reactions of a Species of Surface Isopod with those of a Subterranean Species. *J. of Exp. Zool.*, **8**, 243–310; 439–488.
2. Bohn, G. Les variations de la sensibilité periphérique chez les animaux. *Bull. Scient. de la France et de la Belgique*, **43**, 481–519.
3. Cowles, R. P. Stimuli Produced by Light and by Contact with Solid Walls as Factors in the Behavior of Ophiuroids. *J. of Exp. Zool.*, **9**, 387–416.
4. Cowles, R. P. Reactions to Light and Other Points in the Behavior of the Starfish. *Papers From Tortugas Lab., Carnegie Inst. of Washington*, **3**, 95–110.
5. Day, Lucy M., and Bentley, Madison. A Note on Learning in Paramecium. *J. of Animal Behavior*, 1911, **1**, 67–73.
6. Galloway, T. W., and Welch, Paul S. Studies on a Phosphorescent Bermudan Annelid, *Odontosyllis Enopla* Verrill: *Trans. Amer. Micro. Soc.*, **30**, 3–39.
7. Galloway, T. W. A Case of Phosphorescence as a Mating Adaptation. *School Science and Math.*, May, 1908.
8. Hess, C. Ueber Fluorescenz an den Augen von Insekten und Krebsen. *Arch. f. d. ges. Physiol.*, **137**, 339–349.
9. Hess, C. Neue Untersuchungen über den Lichtsinn bei wirbellosen Tieren. *Arch. f. d. ges. Physiol.*, **136**, 282–367.
10. Holmes, S. J. The Beginnings of Intelligence. *Science*, 1911, **33**, 473–480.

[1] The italics are the reviewer's.

11. Jackson, H. H. T. The Control of Phototactic Reactions in Hyalella by Chemicals. *J. of Comp. Neur. and Psychol.*, **20**, 259–263.
12. Loeb, Jacques, and Maxwell, S. S. Further Proof of the Identity of Heliotropism in Animals and Plants. *Univ. of Cal. Pub. in Physiol.*, 3, 195–197.
13. Mast, S. O. Reactions in Amœba to Light. *J. of Exp. Zool.*, 1910, **9**, 265–277.
14. Mast, S. O. Reactions to Light in Marine Turbellaria. *Pub. Carnegie Inst. of Washington.*
15. McGinnis, Mary O. Reactions of *Branchipus serratus* to Light, Heat and Gravity. *J. of Exp. Zool.*, **10**, 227–240.
16. Moore, A. R. On the Righting Movements of the Starfish. *Biol. Bull.*, **19**, 235–239.
17. Morgulis, Sergius. The Movements of the Earthworm: A Study of a Neglected Factor. *J. of Comp. Neur. and Psychol.*, **20**, 615–624.
18. Morse, Max W. Alleged Rhythm in Phototaxis Synchronous with Ocean Tides. *Proc. Soc. Exp. Biol. and Med.*, **6**, 145–146.
19. Parker, G. H. The Mechanism of Locomotion in Gastropods. *J. of Morphol.*, **22**, 155–170.

RECENT LITERATURE ON THE BEHAVIOR OF THE HIGHER INVERTEBRATES

BY C. H. TURNER

Sumner High School, St. Louis, Mo.

Tropisms

Loeb claimed that, in water, blow-fly larvæ are positively geotropic, but not so under any other circumstances. Recently Mast (9) has conducted some experiments, in both air and water, which militate against this induction. In the air experiments, the larvæ were placed in glass jars. The small larvæ moved about in every possible direction; the larger larvæ crawled upwards, but frequently turned and started in other directions. When such larvæ approached the horizontal, they either fell to the bottom, or each time the posterior end of the body was raised in the process of looping, it swung downward somewhat, thus producing an orientation with the anterior end up. To test their reactions in water, larvæ 6 mm. long were placed in a glass jar containing water 20 cm. deep. All of the larvæ reached the bottom, but there was no evidence of either swimming or orientation; in many cases the longitudinal axis was nearly horizontal. From these experiments Mast concludes that blow-fly larvæ do not react to gravity either in the water or out of it. According to Loeb's definition of a tropism, this conclusion is sound.

Holmes (7) has conducted experiments which he thinks prove

that larval mosquitoes are positively phototactic, but that their reaction to shadows is something more than a tropism. Whenever a shadow was cast upon a larval mosquito, the insect swam downward; this was true even when the shadow was cast upwards by a light placed beneath the aquarium. Holmes considers this a specific reaction to a shadow, which reaction is tinged with a little negative phototaxis. The larvæ were found to vary greatly in their phototactic response; some were indifferent, some moved towards the light and others away from it; but all reacted towards shadows in the manner here described. There was no orientation, and, upon arrival at the positive side of the dish, the position of the body bore no relation to the direction of the rays of light. Age made little difference in reactions. Larvæ that were frequently exposed to shadows gradually ceased to respond to them. The adults, likewise, showed a combination of responses to light; but were more apt to settle on dark than on light objects, and, during the day, they sought the shade, even when it was not hot or dry. At night they sometimes flew towards the light. Some species showed marked positive phototaxis. Eating a full meal did not alter the phototactic response.

Bohn (2) found that the caterpillars investigated by him, when confronted with a cylindrical object, whether it were a part of a plant or a rod, always moved along the body in the direction of its length. When the larvæ were confronted with a series of illuminated patches, in a graded series, up to a certain point the caterpillars were positively phototactic; beyond that point they were negatively so. Parasitized and well-nourished caterpillars were negatively phototactic, while non-parasitized and poorly nourished forms exhibited positive phototaxis. According to Bohn, these tropisms force the parasitized and well-nourished caterpillars to seek dark crannies in which to weave their cocoons, and induce the non-parasitized and poorly fed to find the plants upon which they feed.

According to Andrews (1), termites, although blind, respond to light by collecting where the intensity of the light is least. Andrews does not call this a tropism, but Bohn would.

Differential Sensibility

Lately Bohn has been laying much stress upon what he calls the law of '*sensibilité différentielle*,' which law he claims to have been the first to enunciate. In a recent communication (2), he gives as types of the workings of that law the tendency, so common among many inferior animals, to turn through an angle of 180° when con-

fronted with an abrupt change in the mechanical, physical, or chemical condition of the environment. In the same communication, Bohn gives the following examples of the working of the law. When placed in a dark dish and carried into a dimly lighted room, caterpillars move towards the window. If a dark veil is held at a certain distance above a dish containing caterpillars and then suddenly removed, the caterpillars immediately scatter in all directions. When a dish is partially covered with a dark veil, the caterpillars move towards the shadow; but at the edge of the light, if the contrast is marked, they halt, deviate, or even retreat. If under the term '*sensibilité différentielle*' we include all non-orientational responses to an abrupt change in the environment (and any definition narrower than this would exclude the third example cited from Bohn), the term is synonymous with what Jennings has called 'reaction to change,' and with what Loeb has styled '*Unterschiedsempfindlichkeit.*' Although we may feel that differential sensibility, a translation of Bohn's term, makes a good English name for the phenomena, yet the credit for first stressing the importance of this factor in behavior must be given, not to Bohn, but to Jennings, who discussed the matter as long ago as 1904.[1]

Sensations

1. *Vision.*—During the past year two investigators, Turner (15) and Lovell (8), have reported experiments which they think demonstrate that the honey bee possesses color vision. Although the conclusions of these two investigators are essentially the same, their methods are different. Turner used colored discs, colored cornucopias and colored boxes, all of a small size. After a few bees had acquired the habit of collecting honey from a disc of a certain color, three different series of experiments were conducted; one with discs, one with cornucopias, and one with boxes each provided with a small opening. In each of these series a large number of artefacts of two colors, half of which were of the color of the disc from which the bees had learned to collect honey, were scattered, promiscuously, among the flowers from which the bees were foraging. The artefacts of the color from which the bee had learned to collect honey were supplied with honey, the others were not. All of the artefacts containing honey were visited by numerous bees; no bees visited the other artefacts. Control artefacts of the color from which the

[1] Jennings, H. S. The Behavior of Paramœcium. *J. of Comp. Neur. and Psychol.*, 1904, 14, 464–468. *The Behavior of Lower Organisms*, 1906.

bees were collecting honey were well supplied with honey and placed in portions of the field where the bees had not been trained to feed from artefacts. Although the bees were numerous, these artefacts were not visited. At the close of both the second and the third series of experiments, all of the artefacts were removed from the field; and two artefacts, one of each color, both new and neither containing honey, were exposed in the field. In a few minutes, the artefact of the color that had formerly marked the artefacts that contained honey was completely packed with struggling bees. No bees were in the other artefact. In each series the artefacts were distributed in both the sunshine and the shadow. All were equally visited by the bees. Since the brightness content in the two cases was different while the color was the same, it was concluded that the bees were reacting to colors as such.

Lovell trained bees to collect honey from a glass slide superimposed on a piece of colored paper. He then poured honey upon several pieces of glass, each of which rested upon a piece of colored paper. These slides were arranged in a row and the order changed from time to time. The bees collected from only those slides that covered pieces of paper of the color of the one from which the bees had been trained to feed. No attempt was made to rule out grayness as a factor.

In daylight the caterpillars studied by Bohn (2) moved towards dark bodies. When such a body was moved away, all of the caterpillars would follow it. When it was suddenly moved towards them, they often halted and made a half turn, as though they saw and were reacting according to the law of differential sensibility.

As a result of observations made on the mating of *Dysdera crocata*, Petrunkevitch (13) reiterates his statement that sight is the only means of sense-recognition in hunting spiders.

Pearse (12) has conducted a series of experiments for the purpose of determining if the reactions of protectively colored arthropods indicate that such animals realize that their coloration is advantageous on certain backgrounds, but not on others. Limited space forbids a description of the well-planned experiments. He concludes: "It cannot at present be affirmed that any protectively colored arthropod reacts towards colored objects or backgrounds in such a way that it can be said to have even an instinctive knowledge that it is protectively colored; *i. e.*, arthropods do not choose the most favorable color environment on account of color."

2. *Hearing.*—Andrews (1) furnishes evidence that termites are

affected by concussions of air, leading them to retreat to the nest after thunder, etc. He does not definitely state that they hear; but he expresses the belief that these concussions affect special organs, resembling the ears of locusts, found on each of the legs of the termites.

Mating and Nest-Building Instincts

Petrunkevitch (13) describes in detail the courtship of *Dysdera crocata.* He found that the female made no objection to the approach of the male. Vision enables the male to recognize the female and touch is the chief means he uses to incite the female and to test her willingness to accept him.

Viehmeyer (17) in the published results of some recent researches asserts: (1) *Formica sanguinea* was originally a robber ant: its slavery and its social parasitism have developed out of its robber habits and not out of a previous adoption stage; (2) the colony is founded in the following three ways, through the stealing of pupæ by the females, through alliance with subsequent stealing of pupæ, through adoption; (3) ontogenetically these three forms of colony building are an adaptation to the condition in which the colony is founded by means of slaves; (4) phylogenetically they represent stages in the degeneration of *Formica sanguinea.*

Wasmann (18) gives examples of the following six methods of colony founding by *Formica sanguinea:* (1) by stealing of pupæ by the female; (2) by the peaceful adoption of the female by old workers of the 'help-ant' species; (3) by the peaceful alliance of females of different kinds; (4) by colony-splitting (migration), *i. e.*, by the help of workers of the same species; (5) by the accidental finding of pupæ by the female; (6) by the adoption of a female by a strange colony of the same species. Wasmann defines the terms *pleometropism* and *allometropism* and makes subclasses under each; by the former he means the existence of two or more females of the same species in a nest, by the latter the existence of females of two or more species in the same nest.

Brun (3), as a result of studies of artificial and natural mixed colonies of *Formica rufa*, states that in this species new colonies are formed both by migration and by adoption, and concludes that the artificial and even the more natural alliances of the species are phenomena of complicated, psychically plastic activities, in which, now singly, now in combination, the following factors play a rôle: the disturbance of normal instincts by a powerful stimulus, the supplanting of one instinct by another, psychical contrast effects, the

rapid association of new stimuli with each other and with retained elements.

Fighting and Hunting Instincts

Wasmann (18) relates an instance of a nest of *Formica sanguineas* being slaughtered and eaten by the slaves of that colony.

Brun (3) describes a battle between *Formica rufa* and *Lasius fuliginosus* which had a remarkable ending. Workers, females, and young from several different nests of the former species were collected in a common sack and dumped near a colony of the latter. Having been defeated by the *Lasii*, the *rufas* organized an orderly retreat and, fighting as they departed, retreated in the direction of a *rufa* nest. On nearing the nest, the inhabitants rushed out, joined the defeated *rufas* and drove the *Lasii* back home. Then the miscellaneous collections of *rufas* became an integral part of the foreign *rufa* colony with which they had become so strangely allied.

Sanders (14) describes a series of conflicts between a certain nest of *Myrmica scabrinodes subuleti* Meinert and two neighboring nests of *Lasius niger americanus*. The conflict started between the *Myrmicas* and one nest of the *Lasii*, the second nest of *Lasii* taking no part until the last conflict. On the first approach of the *Lasii* a *Myrmica* rushed into the nest and returned with two companions. These three rushed into the nest and returned with an army. The *Myrmicas* formed a line of battle and soon defeated the *Lasii*. On returning to their nest, the *Myrmicas* left about twenty ants on guard near the nest of the *Lasii*. All subsequent conflicts, except the last, were essentially a repetition of this one; only each time fewer and fewer guards were left by the *Myrmicas*. At the last conflict, after the *Myrmicas* had formed their line of attack, which, as usual, was strongest in the middle, the second nest of *Lasii* approached in the rear of the *Myrmicas'* line of battle. Thus outflanked, the *Myrmicas* broke rank and rushed around the end of the *Lasii* to their own nest. Sanders thinks these conflicts show that the ants profit by experience and that the *Myrmicas* realized the futility of leaving guards to watch the *Lasii*. The first conclusion seems justified; but the latter is hardly proven.

It is well known that certain European Ammophilas stock their nests with subterranean caterpillars which they dig from the ground. The majority of the American students of this group write as though American forms never do so. Recently (16) it has been shown that some of the American Ammophilas have the same habit.

Harvesting Habits

Neger (11) has made a number of observations on *Messor barbarus* which seem to warrant the following conclusions: There is no evidence to justify the statement that ants prevent seeds from sprouting by drying them, for the seeds brought out to dry have already sprouted. The germination of the seed does not, as a rule, extend beyond the first stages; and in seeds which the ants dry in the sun there is no transformation of starch into maltose and dextrine. The seeds, which have been shelled and dried, are taken into the nest, cut into small pieces, chewed well and made into dough. This dough, in the form of crumbs, is brought to the surface and dried to the consistency of biscuits. On account of their hardness, these dried 'biscuits' seem unsuited for nourishment; hence Neger thinks they are used as a substratum upon which to grow a fungus, probably *Aspergillus niger*. This is a leaf cutting species; all of the grass and leaves near the nest are cut down and carried inside.

Miscellaneous Instincts

Morris (10) thinks that the leaf rolling of the oak-leaf rollers is instinctive, but that it is not absolutely perfect. Scattered through his paper are many notes on the habits of beetles.

Symbiosis and 'Amikalselection'

The following opinions of Wasmann (19) on symbiosis and '*Amikalselection*' will prove of interest to students of animal behavior. Symbiosis among ants occurs where the adult ants and the guest insect live together on friendly, mutually helpful terms. In symbiosis the guest exudes a product which is used by the host as food; this distinguishes it from parasitism. Although pathological conditions may sometimes occur, yet symbiosis is not a social sickness of the ant city, as Escherich claims. A sharp line must be drawn between symbiosis as such and the evil effects of its over-development. On the part of the host there are two biological foundations for symbiosis: the ant's fondness for good eating and the adoption instinct of ants. *F. sanguinea* possesses an inheritable instinct for caring for *Lomechusa strumosa*; in *F. rufa* this instinct is much less pronounced; in *F. pratensis* and *F. truncicola* the instinct is null, for they eat the larvæ of the above beetle. In opposition to Escherich, it is held that this marked difference in the behavior of these closely allied species can only be accounted for by assuming the existence of a symbiosis instinct.

While granting that personal selection and germinal selection play a small part in the development of this symbiosis instinct, Wasmann contends that the most influential factor is what he calls '*Amikalselection*,' which is defined as the positive, instinctive, selective breeding which ants and termites practice towards their true guests. According to him, the true ant guests and termite guests are a selection product of the symbiosis instinct of their host, brought about by '*Amikalselection*.' To Escherich's contention that the predication of '*Amikalselection*' is an anthropomorphism he replies that no reasoning is predicated. To Escherich's statement that '*Amikalselection*' is only a form of natural selection he replies that natural selection is a negative factor, while '*Amikalselection*' is a positive factor. As far as the host is concerned, '*Amikalselection*' works independently of, and often counter to, natural selection. So far as known, '*Amikalselection*' occurs only among the ants and termites.

Division of Labor

In a paper giving an elaborate treatment of the habits of the termites of Jamaica, Andrews (1) makes the following remarks upon the division of labor among them: "The workers do all the mechanical work; bite off and transport the wood; feed the soldiers, and males and females; clean the males, females and soldiers; remove the eggs from the orifice on the end of the female and clean and transport them; do all the work of arcade and nest building and all the biting in defense of the community. The soldiers do no mechanical work, except to move themselves; they appear first when the nest or arcade is disturbed, they explore what is novel, lead the advance of processions, stand placed like guards along the sides of processions. They respond to anything unusual rather by exploratory advances than by retreat; being the quicker moving and more responsive members of the community. They form the 'investigator' rather than the soldier caste. Yet they fight, in a refined way, by ejection of a secretion that binds the enemy fast."

As the result of a series of well planned experiments, extending over several years, on the division of labor among ants Miss Buckingham (4) reaches the following conclusions: In *Camponotus americanus* there seems some evidence of division of labor correlated with polymorphism; this is not marked by hard and fast lines, since all classes may share in any activity, but by a preponderance of large ants in fighting, of those of medium size and smaller in building, of those of small size in tending the young, and

of those of small and medium size in foraging. As a rule, the small and medium-sized workers are more active than the largest ones. In *C. herculeanus pictus* there is no hard and fast morphological or physiological distinction between the classes; but the intermediates and minors excel in household duties and foraging and the majors are relatively inactive in all occupations except fighting. In *Phidole pilifera*, there is no hard and fast line between the duties undertaken by the separate classes; but the minors show greater activity in foraging and all household duties and are more active than the soldiers. Callow ants do not fight: this, Miss Buckingham thinks, may account for the fact that the young of different species will dwell together amicably, forming mixed colonies. This is certainly a much more plausible theory than the one proposed some years ago by Miss Fielde.

Homing

Cornetz (**5, 6**) has recently published the results of an extended series of observations on the homing of five species of ants, four of which had poor powers of vision. His conclusions are as follows: Ants are not guided by a homing instinct; for, after a rain, ants carried a short distance from home cannot find the way back. Ants are neither led home mechanically by the odor of the outgoing trail, as claimed by Bethe; nor by a kinematic reverse of the movements of the outgoing ant, as held by Piéron, for the path of the incoming ant never coincides with that by which it left the nest. Ants have a vague notion of the distance traveled and of the angles made. A lone ant, returning to the nest from a distance, is guided by a memory clue, which was acquired during the outgoing passage of the ant; and an ant that has not traveled outward to the hunting ground cannot find its way quickly and directly to the next. Except the statement that the incoming trail never coincides with the outgoing, the above statements agree perfectly with a portion of the results published, five years ago, by the writer of this review in his dissertation on 'The Homing of Ants.' The numerous illustrations published by Cornetz show that the trails of the ants studied by him were not identical. In my work I have cited numerous instances where the incoming and the outgoing paths were different; but in many of our American ants, the difficulty of deciding whether the two trails are identical or slightly different is so great that I did not then, and do not now, feel justified in asserting that the outgoing and the incoming trails are never identical. The fact that they are frequently different justifies the second conclusion stated above. Cornetz asserts that light had no

effect on the ants studied by him; but it must be remembered that the visual organs of those ants were poorly developed. He further states that when a foraging ant starts home it moves, sinuously, in practically a direct line towards the nest. When near the nest, it makes a few exploring movements, which he has called a '*tournoiement de Turner*,' and then enters the nest.

References

1. Andrews, E. A. Observations on Termites in Jamaica. *J. of An. Behav.*, 1911, **1**, 193–228.
2. Bohn, G. Quelques observations sur les Chenilles des dunes. *Bull. de l'Inst. gén. psych.*, 1909, **9**, 1–7.
3. Brun, R. Zur Biologie und Psychologie von *Formica rufa* und anderen Ameisen. *Biol. Centralbl.*, 1910, **30**, 453–464, 475–496, 515–524.
4. Buckingham, E. N. Division of Labor among Ants. *Proc. Amer. Acad. Arts and Sci.*, 1911, **46**, 425–507.
5. Cornetz, V. Trajets de Fourmis et retours au nid. *Mém. de l'Inst. gén. psych.*, 1910, **2**, 1–167.
6. Cornetz, V. Une règle de constance dans les trajets lointains de la Fourmi exploratrice. *Revue des Idées*, Dec., 1910, 1–16.
7. Holmes, S. J. Reactions of Mosquitoes to Light in Different Periods of their Life History. *J. of An. Behav.*, 1911, **1**, 29–32.
8. Lovell, J. H. The Color Sense of the Honey Bee: Can Bees Distinguish Colors? *Am. Nat.*, 1910, **44**, 673–692.
9. Mast, S. O. Do Blow-fly Larvæ Respond to Gravity? *Biol. Bull.*, 1910, **18**, 191–192.
10. Morris, F. J. A. Beetles Found About Foliage. *Canadian Entom.*, 1911, **43**, 109–118.
11. Neger, F. W. Neue Beobachtungen an koernersammelnden Ameisen. *Biol. Centralbl.*, 1910, **30**, 138–150.
12. Pearse, A. S. The Influence of Different Color Environments on the Behavior of Certain Arthropods. *J. of An. Behav.*, 1911, **1**, 79–110.
13. Petrunkevitch, A. Courtship of *Dysdera crocata*. *Biol. Bull.*, 1910, **20**, 127–129.
14. Sanders, G. E. Conflicts between Ants. *Report Entom. Soc. of Ontario*, 1910, **40**, 51–54.
15. Turner, C. H. Experiments on Color Vision of the Honey Bee. *Biol. Bull.*, 1910, **19**, 257–279.
16. Turner, C. H. A Note on the Hunting Habits of an American Ammophila. *Psyche*, 1911, **18**, 13–14.
17. Viehmeyer, H. Ontogenetische und phylogenetische Betrachtungen ueber die Koloniebildung von *Formica sanguinea*. *Biol. Centralbl.*, 1910, **30**, 569–580.
18. Wasmann, E. Nachträge zum sozial Parasitismus und der Sklaverei bei den Ameisen. *Biol. Centralbl.*, 1910, **30**, 453–464, 475–496, 515–524.
19. Wasmann, E. Ueber das Wesen und den Ursprung der Symphilie. *Biol. Centralbl.*, 1910, **30**, 97–102, 129–138, 161–181.

RECENT LITERATURE ON THE BEHAVIOR OF VERTEBRATES

BY PROFESSOR MARGARET FLOY WASHBURN

Vassar College

Fish.—Parker (13, 14) has been studying the sense of smell in the catfish and the killifish. He finds by tests on a freshly prepared fish head that currents pass into the anterior olfactory cavity and out of the posterior one in the case of the catfish, but that in the killifish, instead of such a continuous current, there is an intermittent one depending on respiration. Tests were made on the catfish with wads of cheesecloth, one containing minced earthworm, the other empty. The former was seized, the latter neglected. Fish with the olfactory tracts cut but the barblets, carrying the taste organs, normal, did not seize the food bag. Parker thinks this is evidence of a true sense of smell, a distance receptor. In the killifish, the empty bag was oftener seized, indicating that this fish uses the sense of sight more than the catfish; but operations on the killifish excluding the organ of smell did produce a loss of discrimination between full and empty packets, so that smell does play a certain rôle in this fish also.

Sheldon (16) reports that the dogfish can find hidden food, can discriminate between a packet containing a stone and one containing a crab, and fail to react to the presence of food if their nostrils are plugged. Like the killifish, they get a current of water through the olfactory openings by means of respiratory movements.

Bernoulli (2) has repeated Zenneck's experiments on hearing in fishes, testing trout and eels in open water by an electric bell, C3 in pitch, firmly fixed to its support, and rung under water. He got not the slightest evidence of reaction to the sound.

Parker (15) has published a study of the sense-organs of the dogfish. There is no skin sensitiveness to light in this animal. When the nictitating membranes are stitched together, so that the retinal images are abolished while awareness of light and darkness remains, the fish seek the light in accordance with their positive phototropism, but collide with objects in their path, showing that the retinal image is a guide in locomotion. The sensitiveness of the fish to the striking of a pendulum against the walls of the aquarium was very greatly reduced by cutting the eighth nerve, but was unaffected by cutting the optic nerve and by rendering the skin insensitive. The otoliths seem to be concerned rather with hearing than with equilibrium, as

removing them leaves the balancing powers unaffected. In opposition to Lee, Parker holds that the lateral-line organs are not specially concerned with equilibrium. Like the lateral-line organs, the ampullæ of Lorenzini are stimulated by pressure. The whole skin is sensitive to pressure.

Bauer's (1) method of testing the color sense in fish was to place the fish in a trough with blackened sides, the source of light being at one end, and diffuse light being admitted through the roof of the trough. The sources of colored light were sometimes cards and sometimes filters. The chief results of his experiments are as follows: (1) *Charax puntazzo* and *Atherina hepsetus* have an 'aversion' to the color red as a color. This is concluded from the observation that they swim away if anything red is brought near the open end of the trough, although the former fish is neither positive nor negative in its response to light, and both species will swim towards objects of any other color. (2) *Box salpa* seeks blue as a color: this is concluded from the fact that the fish, which is positively phototropic, prefers blue to white. (3) *Atherina hepsetus* and a species of Mugil show the Purkinje phenomenon, inasmuch as if a green is made lighter than a blue, so that the light-adapted fish seek the green, the dark-adapted fish will seek the blue. (4) Atherina's 'aversion' to red as a color is shown by the fact that if blue and red are so graded in intensity that the dark-adapted fish seeks the red, after light adaptation the fish goes to the blue even if it is very dark. Atherina is positive in its phototropism.

These experiments are rather severely criticized by Hess (10). He points out the inexactness involved in the varying methods of applying the color stimuli, and the apparent contradiction between the observation of the Purkinje phenomenon in Atherina and that of the result numbered (4) above: "the two cannot possibly both be true." So far as Bauer's alleged facts can be accepted, they can all, Hess thinks, be explained on the hypothesis that fish do not see colors as colors, but in the same brightness as a color-blind human being sees.

Amphibians and Reptiles.—Hess (11) has extended his researches on vision to amphibians and reptiles. His two principal methods are: (1) observing an animal's ability to pick up food illuminated by different intensities and qualities of light; (2) finding what intensity of white light is indistinguishable from a given color for animals that have a tendency to seek light. The present article summarizes his conclusions, not only for the two classes of animals just named, but

for all that he has tested. He finds that for fish, the relative brightness of different parts of the spectrum agrees with that for the color-blind or dark-adapted human eye; that for all other classes of vertebrates the spectrum has the same limits of visibility as for the light-adapted human eye; that the Purkinje phenomenon holds for amphibia, and that they seem to have the same color sense as man; "they behave in these experiments otherwise than as a color-blind human being would do." Further, reptiles and day-birds show a shortening of the spectrum at the blue end, probably due to the oil-globules. This shortening is greater in the turtle than in the fowl, and turtles have more orange globules. The pupillar reflex is present in birds but not in turtles. Adaptation phenomena occur even in rodless (turtle) retinas, and thus cannot be due to the rod-pigment. Apes have the same spectral range as man, and their faint light spectrum has the same brightness distribution. Probably their light and color sense agrees more or less closely with man's. This conclusion is of interest because it conflicts with the observations of Watson showing a low stimulating power of red on the monkey retina.

In Casteel's (4) study of the visual discriminations of *Chrysemys marginata*, the choice was offered between two boxes, food being given in one and an electric shock in the other. Four turtles learned to discriminate a black box from a white one, and one turtle failed to do so. None of the turtles learned to discriminate between two patterns, but these patterns were really so similar, owing to their being constructed so as to show an equal area of white, that the failure is not surprising. "Two turtles learned to discriminate between two series of parallel lines 8 mm. wide, one vertical and one horizontal in direction, and showed a fair degree of discrimination when these lines were reduced to 4 mm. in width. One of these turtles did well with a further reduction of the lines to a width of 2 mm." "Two turtles learned to discriminate between two series of parallel horizontal lines 8 mm. and 2 mm. in width respectively. One turtle learned first to discriminate between two series of parallel vertical lines 8 mm. and 1 mm. wide, next between lines 4 mm. and 1 mm. wide, then between lines 4 mm. and 2 mm. wide, and finally showed an excellent average of discrimination between lines 3 mm. and 2 mm. in width." About 183 trials were on the average needed to establish discrimination.

Cole (6) finds that brainless leopard frogs suspended with the hind legs dipped in solutions of ammonium and potassium chlorides

withdraw the legs more rapidly than when sodium and lithium chloride are used. The order corresponds to the degree of dissociation of the salts, which probably determines the time required for diffusion. A complicating factor is that of summation of stimuli. That the reactions are due to a chemical rather than to a pain sense is indicated by the fact that they persisted when ordinary pain reactions were abolished by cocaine.

Mast (12) gives a careful description of the mode of egg-laying in the loggerhead turtle.

Birds.—Herrick (8) has given an interesting account of field observations, made by means of mirrors, on the development of the young American black-billed cuckoo. He distinguishes three stages: the period of infancy, to five days after hatching, during which the grasping reflex, food reactions, the call note reaction, and the righting reaction are noted; the complete quill stage, about the sixth or seventh day, in which the birds sit up, notice sounds and visual stimuli more, peck at insects, preen themselves, and show fear; and a well-marked climbing stage, which lasts about fourteen days, during which the birds leave the nest and jump or climb about on the tree. The origin of the parasitism of the European cuckoo Herrick thinks due to "a change in the rhythms of the reproductive activities," the eggs being laid at more widely separated intervals than is the case with other birds. The American cuckoo shows a trace of this disturbance, but the difficulty of rearing the young thus produced has been met in the case of the American bird not by parasitism, but by the occurrence of the climbing stage, which enables the young to leave the nest at different times.

The same author (9) has published the first part of a study of the nest-building instinct, in which the most important feature is a classification of birds' nests on the basis of the type of behavior which they involve. Space does not permit giving the classification in full, but it is based on such principles as whether the bird has constructed the nest or adapted natural formations to the purpose of a nest; whether the nest is individual or coöperative, whether it is excavated or constructive; whether it is a standing nest or pendent.

L. W. Cole (5) has tested for chicks the law of Yerkes and Dodson that the optimal strength of stimulus for learning decreases the more difficult the discrimination required. The Yerkes brightness discrimination apparatus was used. Three differences in brightness were employed. For the medium difference the optimal strength of stimulus was less than for the greatest difference; and in the most difficult discrimination, while all the chicks learned under the weakest

stimulus used, two out of five failed with the strongest stimulus. So far, the law is confirmed; but the chicks which learned at all with the strongest stimulus learned more rapidly than they did with the weak stimulus. This unlikeness in the behavior of different chicks Cole thinks is explained by the fact that the chicks which failed were those which happened to make more wrong trials at the outset, and were discouraged from making further choices by the number of painful stimuli they received. The law does not, therefore, apply within the same limits as for mice, but it applies to a certain extent.

Watson's observations (19) on the homing of Tortugas terns were interfered with by the weather last summer. He got some instances of long-distance homing, however, and by plugging the nares found evidence that a nasal sense is not involved.

Mammals.—Bogardus and Henke (3) have found that white rats with the vibrissæ removed use nose and head contacts with the corners of a maze to guide them in the learning process, although no contacts need be made when the running has become automatic. Further, in learning a second maze altered in its middle portion from the first, the rats do better if the altered part is placed near the entrance, giving them a long familiar final part to traverse; they learn to make new short circuits more easily than to enter former cul-de-sacs; and they learn to take a new turn more easily the nearer to it the old path is blocked.

In the first section of Waugh's (20) paper on vision in the mouse five problems were investigated: discrimination of light intensity, color discrimination, perception of form, perception of the distance of an object from the animal, and perception of the third dimension of objects. Brightness discrimination was tested by boxes with black and white papers on them, light and dark violet also being used; and by the Yerkes apparatus for direct illumination. A novel feature of these tests lay in an attempt to show, by changing the backgrounds behind the boxes from light to dark, how far the discrimination previously established had taken account of the background. It was found that the background had had considerable influence. Color tests were made with Bradley orange-red and blue papers, between which the mice were able to distinguish; and with red, green, and blue filters. There was no ability to discriminate these colors: red of equal brightness with white to the human eye was discriminated from white, but the power to distinguish between them fell away as the brightness of the red increased, suggesting that the discrimination was based on brightness. Tests were made on brightness and color preference

by offering the mouse different yarns to use in making a nest. Black and white were preferred to grays, and red and yellow to blue and green. Albino mice did not discriminate brightness so well as the others, nor did they distinguish red from white light. Tests with two cards having differently shaped openings showed little power to discriminate form. Distance perception was studied by placing the animals on a small disk which could be raised to different heights above a bench. The fact that the mice jumped more readily from the lower heights was taken as evidence that vision functions in the estimation of distance under these conditions. Another test was made by means of a box with two adjustable partitions, each extending half way across the width of the box, from opposite sides, in such a way that if one partition was nearer the end than the other a passage was left between them. If the right hand partition was nearer, escape could be had by turning to the right around the end of this partition: if the left hand partition was nearer, the turning had to be made from the left. The mice proved unable to judge from the end of the box which partition was nearer and govern their turns accordingly. It may be noted in criticism that this test really demanded not merely distance perception, but a very high type of learning which would hardly be expected of the mouse.

That a small field of binocular vision exists in the mouse was concluded from observing that the two eyes of the animal can both be seen at once from a certain range of positions. The mouse seems not to make eye movements for fixation and convergence, and a microscopical study of the retina revealed no fovea. All parts of the retina are probably equally sensitive. No cones were found.

Shepherd (17) seems to have established the fact that raccoons can be taught to discriminate between the sound of their own individual names and other articulate sounds.

Hamilton's (7) Study of Trial and Error Reactions reports a novel type of test. The subjects were a normal man, seven children ranging in age from fifteen years to twenty-six months, a defective man and a defective boy, five monkeys, sixteen dogs, seven cats, and a horse. The apparatus was as follows: a room was constructed from which exit could be had from one of four doors, and the particular door which could be opened was changed from experiment to experiment. The types of behavior displayed by his subjects Hamilton classifies as follows. In Type A, the recation includes a single definite effort to open each of the three inferentially possible doors, and does not include an effort to open the inferentially impossible door, *i. e.*, the one which was the exit door in the preceding test. Behavior of

this type means awareness of the impossible door as such. It was found in all the human subjects above eight years of age except the defective man. Type B involves trying all four doors, once each, in irregular order. This type was found with diminishing frequency in the defective man, the monkeys, dogs, cats, and least in the horse. Type C involves opening each door once, in a definite order, beginning with one end of the row. This is especially apparent in the young monkeys and a defective boy, although it is also shown to a considerable extent by the dogs. Type D "involves the error of making more than one . . . effort to open a given door during the same trial," but always with an interval of attempts to open the other doors. This recurrent tendency to try a particular door reaches its maximum in the mature dogs, and decreases lower down in the animal scale. The lowest type of behavior, E, involves repeated efforts to open the same door or group of doors without trying others in the interval; or continued avoidance of one door. It increases in frequency as we pass from higher to lower and from older to younger animals; it is almost wholly lacking in the mature human beings, even the defectives, but is frequent in the infant.

The most important results of Shepherd's (18) work on monkeys may perhaps be summarized under three heads: those on color vision, on auditory discrimination, and on ideas. The method of testing color vision consisted in offering the animal a choice between bits of rice dyed different colors, the pieces of a certain color having been soaked in quinine. Color vision is inferred because the monkeys that had learned to avoid red rice in red-white tests avoided pink rice in pink-green tests. To suppose that owing to the brightness difference between red and pink to the human eye this behavior could not have been based merely on brightness discrimination is to neglect the possibility that the brightness value even of pink may be less than that of green to the monkey eye. The monkeys proved able to discriminate a considerable difference in the loudness of two noises and a difference of two octaves in pitch: no tests were made with smaller pitch differences. Some evidence of inferential imitation was obtained. The author thinks that the presence of ideas, "in the sense of an understanding of a certain relation or situation," is demonstrated by such observations as the following: a long board was placed with one end in the cage and food on the other end, which projected out from the cage beyond the monkey's reach; the animal after pulling at the wire netting of the cage a few moments seized the end of the board and pulled it into the cage. It hardly seems necessary to see in this behavior anything more than the monkey's

racial habits. The board is as it were the nearest portion of the attractive object, and he pulls as his ancestors have pulled at a branch with a nut at the end. It may well be that monkeys have ideas, but this particular piece of behavior hardly indicates the fact any more than do other adaptive but inherited tendencies to movement on the part of animals much lower in the scale.

References

1. Bauer, V. Ueber das Farbenunterscheidungsvermögen der Fische. *Arch. f. d. ges. Physiol.*, 1910, **133**, 7–27.
2. Bernoulli, A. Zur Frage des Hörvermögens der Fische. *Arch. f. d. ges. Physiol.*, 1910, **134**, 633–644.
3. Bogardus, E. S., and Henke, F. G. Experiments on Tactual Sensations in the White Rat. *J. of Animal Behav.*, 1911, **1**, 125–138.
4. Casteel, B. D. The Discriminative Ability of the Painted Turtle. *J. of Animal Behav.*, 1911, **1**, 1–28.
5. Cole, L. W. The Relation of Strength of Stimulus to Rate of Learning in the Chick. *J. of Animal Behav.*, 1911, **1**, 111–125.
6. Cole, L. W. Reactions of Frogs to Chlorides of Ammonium, Potassium, Sodium, and Lithium. *J. of Comp. Neur. and Psych.*, 1910, **20**, 601–614.
7. Hamilton, G. V. A Study of Trial and Error Reactions in Mammals. *J. of Animal Behav.*, 1911, **1**, 33–66.
8. Herrick, F. H. The Life and Behavior of the Cuckoo. *J. of Exper. Zool.*, 1910, **9**, 169–233.
9. Herrick, F. H. Nests and Nest-Building in Birds: Part I. *J. of Animal Behav.*, 1911, **1**, 159–193.
10. Hess, C. Ueber den angeblichen Nachweis von Farbensinn bei Fischen. *Arch. f. d. ges. Physiol.*, 1910, **134**, 1–15.
11. Hess, C. Untersuchungen ueber den Lichtsinn bei Reptilien und Amphibien. *Arch. f. d. ges. Physiol.*, 1910, **132**, 255–295.
12. Mast, S. O. Behavior of the Loggerhead Turtle in Depositing its Eggs. *Carnegie Pub.*, 1910, **132**, 65–67.
13. Parker, G. H. Olfactory Reactions in Fishes. *J. of Exper. Zool.*, 1910, **8**, 535–541.
14. Parker, G. H. The Olfactory Reactions of the Common Killifish, *Fundulus heteroclitus* (Linn.). *J. of Exper. Zool.*, 1910, **10**, 1–5.
15. Parker, G. H. Influence of the Eyes, Ears, and Other Allied Sense Organs on the Movements of the Dogfish, *Mustelus canis* (Mitchell). *Bull. Bureau of Fisheries*, 1909, **29**, 45–57.
16. Sheldon, R. E. The Sense of Smell in Selachians. *J. of Exper. Zool.*, 1911, **10**, 51–61.
17. Shepherd, W. T. The Discrimination of Articulate Sounds in Raccoons. *Amer. J. of Psychol.*, 1911, **22**, 116–119.
18. Shepherd, W. T. Some Mental Processes of the Rhesus Monkey. Psychological Monographs, 1910, **12**, no. 5. Whole no. 52.
19. Watson, J. B. Further Data on the Homing Sense in Noddy and Sooty Terns. *Science*, 1910, **32**, 470–473.
20. Waugh, K. T. The Rôle of Vision in the Mental Life of the Mouse. *J. of Comp. Neur. and Psychol.*, 1910, **20**, 549–599.

SPECIAL REVIEWS

RESPONSES TO LIGHT AND COLOR

Light and the Behavior of Lower Organisms. S. O. MAST. New York: John Wiley & Sons, 1911. Pp. xi + 410.

Two years ago, Miss Washburn, in *The Animal Mind*, gave us our first critical and historical survey of that body of facts which may best be called animal behavior. Her presentation, covering as it did a multitude of facts, could not treat of any one topic in an exhaustive way. The present volume by Mast treats of a limittd portion of the field of behavior—that of orientation to light. When one considers, however, that Mast's bibliography consists of 13 pages of 8 point type, one cannot but feel that if the author is treating of a 'limited' subject, it is at least one which has been studied in a very broad way. As a matter of fact, Mast deals in the book historically and experimentally with those vexed questions of the mechanism of light-orientation (tropism, *Unterschiedsempfindlichkeit*, etc.), the variability and modifiability of such responses, and the adaptiveness or lack of adaptiveness of such responses. The student of behavior who does not find his especial province in the field of lower organisms, and who yet tries to follow this work, knows what an almost hopeless task it is, due to the general complexity of the subject, to the lack of a definite and uniform vocabulary, and to the spirit of strife which so often seems to be the initial impulse to experimentation in this field. Mast's book attempts to deal in a calm and dispassionate way with the actual facts in the case. He lets his controversial spirit appear somewhat, when he discusses Loeb's work. With this exception the book is well balanced.

The volume is divided into four parts: Part I. deals with the historical side of plant and animal orientation. On pages 53 ff. Mast gives some fifteen definitions of tropism: "it is evident that nearly every reaction in any living organism comes under one or another of the various definitions given to the term tropism." So conflicting are the uses of the term that Mast feels that it has outgrown its usefulness, and accordingly avoids it in the book. He uses 'orientation to light' instead of phototropism, etc. Under the general headings of orientation the following pertinent questions may be

asked,—all answerable by experiment: Is orientation direct; does the organism turn directly away from or toward the source of stimulation, or does it become oriented after a series of preliminary movements? How is the stimulus causing orientation produced? By direction of rays through the organism, in accord with the theory of Sachs; by absolute difference of intensity on symmetrically located points on the sensitive surface, in accord with the theories of Loeb and Verworn; or by changes in intensity on the surface in accord with the ideas of Engelmann, Darwin and Jennings? Furthermore, after the animal has become oriented, does light act constantly as a directive stimulus, or only when the organism turns out of its course, thereby producing changes in intensity? Finally, is orientation due to the direct effect of light upon the locomotor appendages (Verworn, Torrey), or to the indirect effect through a reflex arc (Loeb), or finally, is the whole organism involved in the process (Jennings)?

These in part are the questions which Mast sets out to answer, both by consideration of the works of others, and from his own experiments. The author proposes in his experiments to enter very much more deeply into the subject of light responses than was done in the superficial work of Loeb and his followers.

Part II. concerns itself with a detailed experimental answer to the questions just raised. The process involved in plant orientation to light is first discussed. Mast finds in the behavior of plants to light no support to Sachs's ray-direction theory, nor to that phase of Loeb's theory which asserts that symmetrically located points on the surface must be struck by light at the same angle when the plant is oriented. *Orientation is regulated by differences in light intensity on opposite sides of the plumules.*

Then follow the details of orientation in unicellular forms, such as amœba, euglena, stentor, paramecium; in colonial forms as volvox; in cœlenterates, as hydra and medusæ; in vermes as the earthworm and planaria, in fly larvæ and in the echinoderms. Still higher forms are studied, such as arthropods and vertebrates (frogs and toads). While the author is dependent to some extent upon the work of others as to his conclusions, in general he has worked very carefully and thoroughly with most of the forms discussed.

He finds that orientation in such forms as the amœba is due to local response to a local stimulation. Light retards the activity of the protoplasm and thus prevents the formation of pseudopods upon the more highly illuminated area. In forms like euglena, stentor (and probably all the ciliates and flagellates which orient

in light) orientation is due to definite responses to changes of light intensity on the sensitive part of the organism. The rotation upon the long axis of the body brings about, by shading the sensitive area successively, now high, now low intensity. As soon as the animal reaches a position in which the rotation on the long axis no longer causes changes in intensity on the sensitive region, there is no longer cause for turning. Similar factors are involved in the responses of colonial forms. Representatives of the cœlenterates (*e. g.*, hydra), vermes (earthworm, planaria, etc.), mollusks, arthropods and vertebrates, orient directly. In most cases there are a few trial movements. From all this work Mast concludes that orientation may be due (1) to local response to local stimulation (amœba); (2) to shock movement, avoiding reactions as in ciliates, etc.; (3) to differential response to localized stimulation, as in cœlenterates, vermes and the higher forms; (4) to sight proper, as in animals with image-forming eyes.

There is no evidence anywhere in support of Sachs's ray-direction theory, nor of that hypothesis which asserts that symmetrical points must be struck by light at the same angle. Nor is there any conclusive evidence except in the case of animals with image-forming eyes that light acts continuously as a directive stimulus. There is no conclusive evidence that orientation to light is ever due, in any organisms, to tropic reactions, if the definitions of tropism by Loeb, Verworn and Rádl are used as criteria.

All organisms that respond to light respond to changes in intensity. In some cases orientation follows upon these responses; in others it does not. All light response in such organisms is *unterschiedsempfindlich.* They all respond to time-rate of change, as explained by Engelmann, Bert, and Graber, years ago, and more recently by Loeb.

Part III. is given over to a general consideration of responses to light, the adaptiveness or lack of adaptiveness in such reactions, regulation of reactions, variability and modifiability of reactions, etc.

Part IV. deals with reactions to monochromatic light. In this latter part the reviewer would take issue with Professor Mast in regard to the adequacy of the methods used in the study of orientation to monochromatic light. Mast feels that the methods have been adequate; but surely there has been little effert on the part of these investigators to obtain anything like adequate control of stimulation.

The book as a whole gives us another landmark. The author

has been sincere and earnest in his work, conservative in his conclusions and generally temperate in his criticisms.

JOHN B. WATSON

JOHNS HOPKINS UNIVERSITY

The Instinct of Self-concealment and the Choice of Colors in the Crustacea. ROMAULD MINKIEWICZ. Annual Report of the Smithsonian Institution, 1910, pp. 465–485. Translated from Rev. gén. d. sci. pures et ap. Paris, Feb. 15, 1909.

The author brings together here in a general way all of the results of experiments described in a series of seven or eight papers, some originally published in Polish, others in French. Nearly all of these papers have been reviewed in this journal in past years. I wish however to state again a point emphasized in these reviews, *i. e.*, that Minkiewicz maintains that crustacea select and cover themselves with fragments of various kinds but of such a color as to harmonize with their environment. This is in opposition to the results of all other investigators who have made observations along this line. There is consequently much doubt in the minds of some concerning the accuracy of Minkiewicz's observations. In view of this fact and the importance of the subject more experimental observations are highly desirable, especially on the species used by Minkiewicz.

S. O. MAST

JOHNS HOPKINS UNIVERSITY

Certain Habits, Particularly Light Reactions, of a Littoral Aradnead. T. H. MONTGOMERY, Jr. Biol. Bull., 20, 71–76.

This little beach spider, when shaken from eel-grass under which it is usually found, was observed to run persistently landward except when the sun is directly above or when it is obscured. The author found that these animals in the laboratory react negatively to lamp light and sun light, and after demonstrating that their course landward is not the result of responses to moisture, wind or gravity, he concluded that it is due to a negative reaction to light reflected from the water.

It seems to the reviewer however that if this were the only factor directing their course one would expect them to go landward at noon as well as at other times, for surely the differences between the amount of light reflected from land and water at that time is as great as it is at some other times, *e. g.*, when the sun is on the landward side of the beach and its rays strike the water at a rather small angle.

S. O. MAST

JOHNS HOPKINS UNIVERSITY

MEMORY

L'évolution de la mémoire. Henri Piéron. Paris: Flammarion (Bibliothèque de philosophie scientifique), 1910.

It is now more than forty years since Professor Ewald Hering delivered his famous lecture on 'Memory Considered as a General Function of Organic Matter.' Itself clear, brilliant and masterly, that lecture has, nevertheless, more than once offered others occasion for extravagant and confused thinking. Setting out from the principle of psychophysical parallelism, when scientific psychology was in its first beginnings, Hering made it evident that the mnemic basis of reproduction lies in neural 'retention,' and that the property of organic conservation is inherent not only in the human cerebral cortex but in living matter at large. There appeared in the lecture no obfuscation of fact by speculation, no attempt to make the writer's *Fach* a *Grundwissenschaft*, no confusion of brain and mind, and no unwarranted inference out of one science into another. Not so much can be said for most of Hering's imitators; not so much can be said for Piéron's *Evolution of Memory*. Piéron is writing a psychological treatise; yet he begins by repudiating introspection, by confusing the memorial, retrospective consciousness with persistent effects of organic function, and he proceeds by searching the field for an 'objective psychology,'—very much as Lewis Carroll's Bruno may have looked for 'black light,' or as the restless inventors of Balnibarbi tried to fashion sofa-pillows out of marble.

In conscious opposition to his countryman Bohn, the author views the racial development of mind as a continuous process. So far as the function of memory is concerned, he succeeds; but he succeeds only by the help of a definition so broad—*all those facts of behavior that point to antecedent events in the individual's career*—as to rob the term of its psychological significance, and by the disregard of essential differences to be found among the processes of adjustment throughout the animal series.

No general characteristic of mind stands out so plainly from the experimental work of the last ten years as the fact of *determination*. Consciousness flows. Its height, volume, direction and accomplishment depend quite as much upon its head and the tributaries leading down out of the past, as upon its temporary composition and its immediate organic setting. Thinking is carried out under *Aufgabe;* action is dependent upon determining tendency, habituation and practice involve progressive elimination and selection, and emotion runs its course under the pressure of whole generations of affective

experience. The psychophysical organism is well-nigh unlimited in its varied resources for bringing into play the residues of past function. Impressional and reproductive tendencies lie dormant for hours, days, or even years; the brain is shot through with predispositions and sets; the movement-apparatus tingles with prepared coördinations; instructions and suggestions echo and re-echo; and the bed of consciousness is cut deep in the organic foundations of the species. To throw all these together—physical and mental—and to account them as 'memories' is only to confound that which has taken years to distinguish and to set in order.

The sections of the book on the persistence of rhythms beyond the term of the provoking stimulus survey a field where the author has himself done valuable work at first-hand. The core of the book is the part devoted to learning and habituation among animals. It brings together in a helpful way most of the recent literature of behavior and of comparative psychology.

MADISON BENTLEY

CORNELL UNIVERSITY

ANIMAL PSYCHOLOGY

La nouvelle psychologie animale. GEORGES BOHN. Paris: Alcan, 1911. Pp. 200.

We have here a clear and succinct statement of Bohn's attitude with regard to the problems of comparative psychology. The book is divided into three parts, the first dealing with the lower invertebrates, the second with the arthropods, and the third with the vertebrates. The behavior of the first group of animals Bohn thinks may be most profitably studied from the physico-chemical point of view taken by Loeb. It reveals three principal features: tropisms, differential sensibility, and cellular memory. A tropism is a reaction determined by the relative speed of chemical changes produced in symmetrically placed elements on the two sides of an animal's body. The notion of symmetrical structure is essential to the tropism. In the case of differential sensibility we have a pause, a recoil, or a rotation through 180° on the part of an animal affected by a sudden change in the intensity of a stimulus. The rudiments of associative memory are also found in the lower invertebrates. These three factors in behavior are modified by the physiological state of the animal, which in turn depends on the individual's own activities, on its habits of life and individual diathesis, on changes in the environment, and on habitat. The idea of finality should be practically

abandoned in the study of the behavior of the lowest animals; tropisms are often fatal to the animal, although differential sensibility shows more adaptation to the needs of the organism.

The problem of instinct is the chief problem encountered in the study of the behavior of higher vertebrates. Instincts according to Bohn are "complexes of activities into which various elements enter: inherited elements and those due to individual learning; relatively simple elements (tropisms, differential sensibility), and more complicated factors (associations of sensations)." He analyzes the following cases of instinct in arthropods: death-feigning, nest-finding, food-seeking, mimicry, and social instincts.

The development of the brain in vertebrates brings with it an extensive development of the memory factor in behavior. "Intelligence is the appanage of vertebrates." In the discussion of the methods which have been used to investigate the behavior of vertebrates the largest amount of space is devoted to Pawlow's method. The other methods are classified under the terms labyrinth method, puzzle-box method, method of imitation, and method of training (*dressage*); the last two are held to be of distinctly less value than the others.

M. F. W.

BOOKS RECEIVED DURING JULY

Groos, K. *Das Seelenleben des Kindes. Ausgewählte Vorlesungen.* Berlin: Reuther & Reichard, 1911. Pp. 334. Mk. 4.80.

Brown, W. *The Essentials of Mental Measurement.* Cambridge: Univ. Press, 1911. Pp. vi + 154. 3/6 net.

Offner, M. *Das Gedächtnis. Die Ergebnisse der experimentellen Psychologie und ihre Anwendung in Unterricht und Erziehung.* Berlin: Reuther & Reichard, 1911. Pp x + 258. Mk. 3 50.

Dessoir, M. *Abriss einer Geschichte der Psychologie.* Heidelberg: Winter, 1911. Pp. xi + 272.

Mille, P. *Caillou et Tili. Psychologie de l'Enfance.* Paris: Calmann-Lévy, 1911. Pp. 269. 3 fr. 50.

Klemm, O. *Geschichte der Psychologie.* Leipzig und Berlin: Teubner, 1911. Pp. x + 388. Mk. 8.

Sinclair, S. B., and Tracy, F. *Introductory Educational Psychology. A Book for Teachers in Training.* Toronto: The Macmillan Company of Canada, 1909. Pp. xii + 180. $0.90 net.

McKeever, W. A. *Psychologic Method in Teaching.* Chicago: A. Flanagan Co., 1909. Pp. xxi + 332.

NOTES AND NEWS

Dr. Knight Dunlap, of Johns Hopkins University, has been advanced from an associateship to an associate professorship in psychology.

Professor J. H. Leuba, of Bryn Mawr College, recently received the honorary degree of Doctor of Science from Hobart College.

It is perhaps not generally known that the Sarah Berliner Research Fellowship for Women (an annual fellowship of $1,000 "open to women holding the degree of doctor of philosophy or to those similarly equipped" and "available for study and research in physics, chemistry or biology") and the biennial prize of $1,000 offered by the Naples Table Association ("for the best thesis written by a woman, on a scientific subject, embodying new observations and new conclusions based on an independent laboratory research in biological, chemical, or physical science") are open to workers in psychology. Applications for the exact conditions should be made to Mrs. C. L. Franklin, chairman of the Sarah Berliner committee, 527 Cathedral Parkway, New York, or to Dr. Jane Welch, Baltimore, Md., of the Naples Table Association.

The present number of the BULLETIN, dealing especially with comparative psychology, has been prepared under the editorial care of Professor Margaret Floy Washburn.

ERRATA.—Through an unfortunate mishap in the printing office several sentences of our July issue were so mutilated as to render them almost unintelligible. The lines which suffered (page 246, lines 21–26) should read as follows: . . . . compend for readers and investigators of this topic.

In Langfeld's study of association (24), pictures of familiar objects served as stimuli; and the instructions to the reagents differed from those ordinarily given in that the response must not contain the name of the pictured object. Langfeld found that negative instructions are effective in determining associations,—*i. e.*, the *Aufgabe* . . . . . . It is but fair to Dr. Baird to state that none of these misprints appeared upon the author's proof submitted to him, and that he is in no way responsible for the errors which appeared.